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NOTE

SATELLITE-TRACKED CURRENT DRIFTERS IN LAKE MICHIGAN[1]

R. L. Pickett, J. E. Campbell, and A. H. Clites
Great Lakes Environmental Research Laboratory/NOAA
2300 Washtenaw Avenue
Ann Arbor, Michigan 48104

R. M. Partridge
Data Buoy Office/NOAA
National Space Technology Laboratories
Bay St. Louis, Mississippi 39520

ABSTRACT. Satellite-tracked current drifters are being used to monitor near-surface currents in Lake Michigan. These drifters are now commercially available, and preliminary tests show their satellite-determined positions to be within 0.5 km. The drifters appear to be ideal for monitoring near-surface lake currents and testing hydrodynamic lake models.
ADDITIONAL INDEX WORDS: Hydrodynamics, lake currents, Lagrangian currents, remote sensing.

INTRODUCTION

This note presents preliminary results of a test of satellite-tracked current drifters in Lake Michigan. This experiment is the first application of commercially available satellite drifters to monitor currents in lakes.

Although new in their application to lakes, these drifters have been used in the oceans for several years (Kirwin *et al.* 1976). The evolution of these drifters began with ship-tracked drogues. Next, RADAR reflectors were added to the ship-tracked drogues to increase detection range. Radio transmitters eventually added even more range. Finally, a communication system was developed that allowed drifters to be tracked by satellite. The early satellite-tracked versions were handmade and had position errors of 5 km. The modern commercially available versions have position errors of 0.5 km.

The use of satellite tracking offers several advantages over conventional techniques. Ships are not required for monitoring; accurate positions are available every 2 hr; and numerous drifters can be tracked simultaneously. The only disadvantage encountered so far is the cost ($5,000 U.S. per drifter).

METHOD

The four satellite-tracked current drifers used in these tests were manufactured by Polar Research Laboratory in Santa Barbara, California. The model used is one of many commercially available models. Each unit consists of a surface float containing the transmitter and batteries, and a 1-m length of line down to a weighted 1 m × 4 m parachute (See Fig. 1.). The surface unit transmits to TIROS satellites. Its position is determined by Doppler shift as the satellite passes overhead.

Before the drifters were put in the lake, two questions needed to be answered. First, what was the accuracy and dependability of their navigation system? To answer this question, all four drifters were transported to four different land stations around the Great Lakes region. The drifters were left at each location several days to obtain statistical data on the accuracy and frequency of positions. Also, the units were tilted at various angles, laid on their sides (to simulate beaching), and

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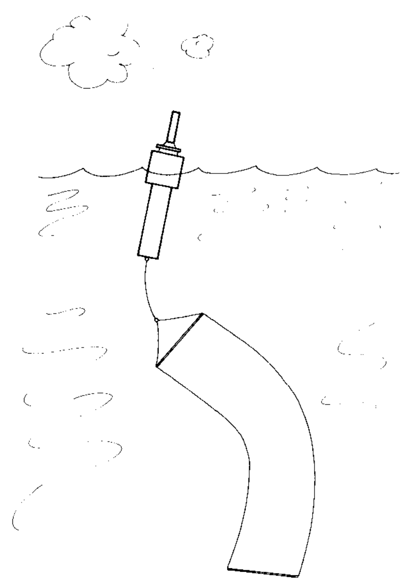

FIG. 1. Sketch of the satellite-tracked current drifter.

placed inside buildings and vehicles to determine if their response would be degraded under such conditions.

The second question concerned how long the drifters would stay offshore in the more limited confines of the Great Lakes (compared to the ocean). Because of the closed nature of a lake's circulation, the drifters should eventually circumnavigate the lake. But strong onshore winds could result in a cross-streamline drift that might beach them. The answer to this question came from watching the drifters as they moved nearshore and by estimating the wind drift. The technique developed by Kirwin *et al.* (1974) was used to estimate the wind drift.

RESULTS

The land tests showed that positions were obtained every 2 hr and were within 0.5 km over the latitude and longitude range of the Great Lakes. Position accuracy did not vary significantly with latitude, longitude, or tilt-angle. Position errors were random and unbiased, and there were more variations between individual drifters than variations due to other causes. In cases where the units were strongly shielded, as for example in a building's basement, the signal was often not received by the satellite. But when a signal was received, the position was still accurate within 0.5 km.

Next, water tests were done. Measurements of the drifters on land and in water showed that the ratio of water-drag area to wind-drag area was 25:1. This ratio would theoretically result in the drifter moving with 99.3% of the current speed and 0.7% of the wind speed. Although this wind effect appears small, gale force onshore winds combined with currents from breaking waves proved capable of driving the drifers onshore.

On 15 September 82 the four drifters were placed on a transect halfway across southern Lake Michigan. They performed as well in the water as they did on land, and positions have been received regularly since then (Fig. 2). Their movement suggests strong northward currents off the eastern shore and slow meandering currents near the middle of the lake.

On an intermediate scale, the drifter tracks show 3- to 5-day changes in their patterns. These changes result from changing wind patterns that modify the lake's overall circulation (see Saylor *et al.* 1980).

On a fine scale, the drifters show clockwise inertial circles. These circles are always present and

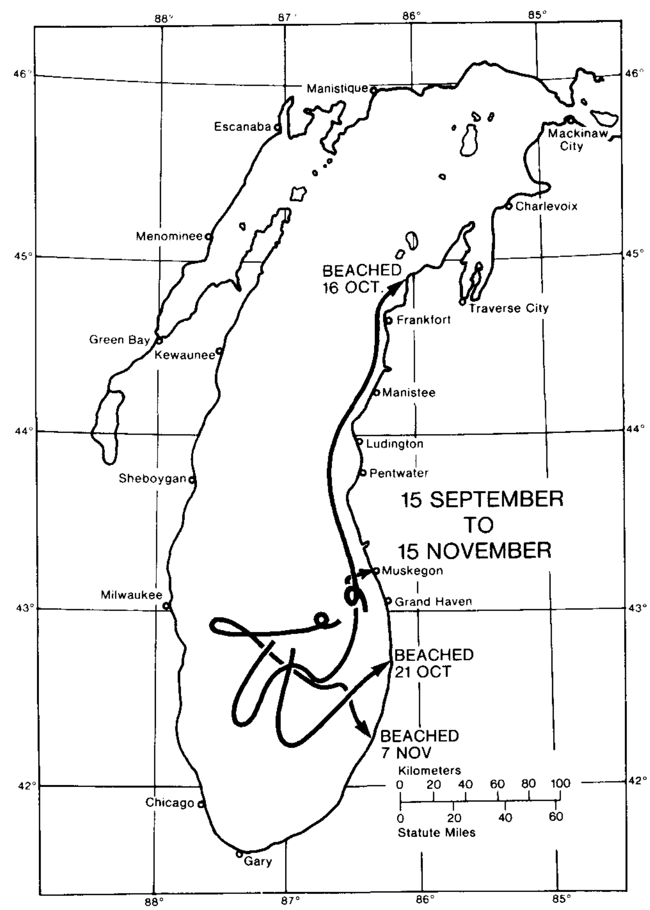

FIG. 2. Paths of drifters from 15 September 82 to 15 November 82.

are only a few kilometers in diameter (hence they do not show up in the smoothed tracks in Figure 2).

The median current speed determined from the drifters was 17 cm s^{-1} and 99% of the speeds were less than 55 cm s^{-1}. The path lengths over the first two months ranged from 400 to 700 km.

The remaining question was how often would the drifters wash ashore? During the first month, they remained offshore. The path followed by the eastern drifter indicates that these units are capable of following a nearshore isobath for a long distance without becoming beached.

After the first month, however, two gales only a week apart drove three drifters ashore. The northern drifter (Fig. 2) was destroyed in the surf by 5-m seas driven by 20 m s^{-1} winds. The southern drifters survived beaching and will be redeployed.

CONCLUSIONS

Satellite-tracked current drifters are useful for monitoring near-surface currents in the Great Lakes. Some typical uses might be in littoral drift, pollutant advection, or residence-time studies.

In our particular case, these units should provide an ideal way to test our spill model (Pickett 1981). This operational, interactive computer model combines forecasted winds and currents to predict the trajectory of a spill. By comparing predicted surface trajectories with observed drifter tracks, accurate operational tests of the model will be possible.

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